A BATHYMETRIC CHART OF CARMEL BAY, CALIFORNIA

RALPH ANTHONY ZARDESKAS

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A BATHYMETRIC CHART
OF
CARMEL BAY, CALIFORNIA

by

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Thesis Advisor: R.S. Andrews

September 1971

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of
Carmel Bay, California

by

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ABSTRACT

This study has as its final product a bathymetric chart of Carmel Bay, California, which is improved over any other previously existing chart. The unique problems of applying the echo-sounding corrections necessary to create accurate bathymetric charts of areas with steep bottom slopes are discussed.

TABLE OF CONTENTS

I. INTRODUCTION -- 10
  A. OBJECTIVE -- 10
  B. DESCRIPTION OF AREA -------------------------- 11
  C. PREVIOUS INVESTIGATIONS ---------------------- 13
II. PROCUREMENT OF DATA ---------------------------- 15
  A. SOUNDING LINES ------------------------------- 15
    1. Echo-sounding Equipment ------------------ 15
      a. Fathometer ------------------------------ 15
      b. 3.5-kHz High Resolution Reflection Profiler ------------------ 15
    2. Sounding Line Spacing -------------------- 15
    3. Sounding Line Layout --------------------- 18
    4. Sounding Lines Accomplished -------------- 19
  B. NAVIGATION ----------------------------------- 19
    1. Navigation Equipment --------------------- 19
    2. Transponder Positioning Requirements ----- 21
    3. Transponder Positioning ------------------ 21
    4. Fixes ------------------------------------ 23
  C. TRACK MAINTENANCE ---------------------------- 23
  D. AREA OF SURVEY COVERAGE ---------------------- 25
    1. Shallows --------------------------------- 25
    2. Kelp Beds -------------------------------- 25
    3. Equipment Limitations -------------------- 27
  E. DATA COLLECTION ------------------------------ 27

III. CORRECTIONS APPLIED ---------------------------------- 29

A. TRANSDUCER DEPTH ---------------------------------- 29

B. TIDE CORRECTION ---------------------------------- 29

C. INSTRUMENT ERROR ---------------------------------- 30

D. SOUND VELOCITY CORRECTIONS -------------------- 30

1. Computation of Mean Vertical Sounding Speed ---------------------------- 32

2. Computation of Sound Speed Error --------- 32

E. SLOPE CORRECTIONS ---------------------------- 32

1. Statement of the Problem ----------------- 32

2. Corrections for Slope Angles Less Than 15° ---------------------------- 33

3. Corrections for Slope Angles Greater Than 15° ------------------------- 33

F. CROSS SLOPE CORRECTION ----------------------- 36

1. Statement of the Problem ----------------- 36

2. Correction for Cross Slope -------------- 37

IV. RESOLUTION OF BATHYMETRIC DATA ------------------ 39

A. DATA REDUCTION ------------------------------- 39

1. Calculation of the Mean Lower Low Water Datum ------------------------- 39

2. Preliminary Annotation of Bathymetric Records ---------------------- 40

3. Application of Slope Corrections --------- 40

a. Calculation of Apparent Echo Slope Angle ------------------------- 41

b. Calculation of Apparent Bottom Slope Angle ------------------------- 41

(1) Echo Slope Angles Less Than 15° ------------------------ 41

(2) Echo Slope Angles Greater Than 15° --------------- 41

c. Calculation of True Bottom Slope ----- 41

d. Final Annotation of Bathymetric Records ---------------------------------- 42

e. Ambiguity of 'V' Shaped Depressions -------------------------- 42

V. CARTOGRAPHY -- 44

A. CONSTRUCTION OF THE SMOOTH SHEET ------------- 44

B. CONSTRUCTION OF THE FINISHED CHART ----------- 44

VI. SUMMARY --- 45

VII. FUTURE WORK -- 47

APPENDIX A: PRECISION DEPTH RECORDER SLOPE CONVERTED TO APPARENT BOTTOM SLOPE ------------------------------------ 48

APPENDIX B: CORRECTIONS FOR TRUE BOTTOM SLOPES LESS THAN 15° ------------------------------ 50

APPENDIX C: CORRECTIONS FOR TRUE BOTTOM SLOPES GREATER THAN 15° -------------------------- 67

REFERENCES CITED --- 104

INITIAL DISTRIBUTION LIST ------------------------------- 105

FORM DD 1473 --- 107

LIST OF TABLES

TABLE

I Sounding Line Spacing for 100% Coverage --------- 17

II Control Point Data ------------------------------ 22

III Instrument Errors ------------------------------- 31

LIST OF FIGURES

FIGURE

1. Location Map of Carmel Bay (from C&GS 5476) ----- 12

2. Definition of 100% Coverage ---------------------- 16

3. Sounding Lines Steamed and Sounding Lines Not Completed --------------------------------- 20

4. Construction of Track Preplot ------------------- 24

5. Track Preplot and Ship's Actual Track ----------- 26

6. Slope Correction for Slope Angles Less Than 15° -------------------------------------- 34

7. Slope Correction for Slope Angles Greater Than 15° -------------------------------------- 35

8. Cross Slope Correction -------------------------- 38

9. Ambiguity of 'V' Shaped Depression -------------- 43

10. Comparison of 1933 and 1971 Bathymetric Surveys -- 46

LIST OF PLATES

PLATE

I. Bathymetric Chart of Carmel Bay, California ---------------------------------- Folded in back

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Further sincere appreciation is given to my mother, Mrs. A.P. Zardeskas, who forced me to study as a youth and whom I have never thanked. Thank You.

I. INTRODUCTION

This paper presents the results of a hydrographic survey of Carmel Bay, California, performed using a 12-kHz fathometer and a 3.5-kHz high resolution reflection profiler. Navigation was accomplished with a two-station range-range positioning system.

The survey was conducted on March 10-12, 1971, from a 52-ft chartered oceanographic survey boat, R/V DAWN STAR, owned and operated by General Oceanographics, Inc., of Newport Beach, California.

A. OBJECTIVE

The objective of this study was to create a bathymetric chart of Carmel Bay, California, which accurately represented the bottom topography. This completed chart, far more detailed than a standard navigational chart, provides a valuable tool to those interested in studying Carmel Bay.

The hydrographic survey was conducted using the best positioning and echo-sounding systems economically available. Corrections were applied to the bathymetric data so as to reproduce faithfully the topographic features of the bottom. During the course of reducing the bathymetric data, equations were derived to handle corrections for the steep bottom slopes encountered in the bay.

The contours on the final chart will not necessarily be the depths that a ship using a standard fathometer would find. The depth corrections were in places very large due to the steep-walled submarine canyon and would cause a vessel to read considerably shallower depths than those indicated on the chart (the depths on the chart being the actual depths).

B. DESCRIPTION OF AREA

Carmel Bay, situated on the central California coast (Fig. 1), is an embayment cut by Carmel Submarine Canyon (a principle tributary of Monterey Submarine Canyon to the north). The head of Carmel Canyon is located close to the beach in the southeastern sector of the bay.

Carmel Bay is protected to the north and south by Cypress Point and Point Lobos, both of which are composed of Cretaceous Santa Lucia granodiorite. Granite Point, Pescadero Point, and the southern half of Abalone Point are also made up of granodiorite. Arrowhead Point and the northern side of Abalone Point are made up of Miocene volcanics.

Carmel Beach, Pebble Beach, Stillwater Cove, and Whaler's Cove have been formed by the weathering of Paleocene Carmelo pebble conglomerate. Dune sands can be found at the north end of Carmel Beach.

Carmel Submarine Canyon is formed by subaerial erosion in solid rock along a possible fault trace (Martin, 1964, p. 54). The major sources of sediment into Carmel Bay

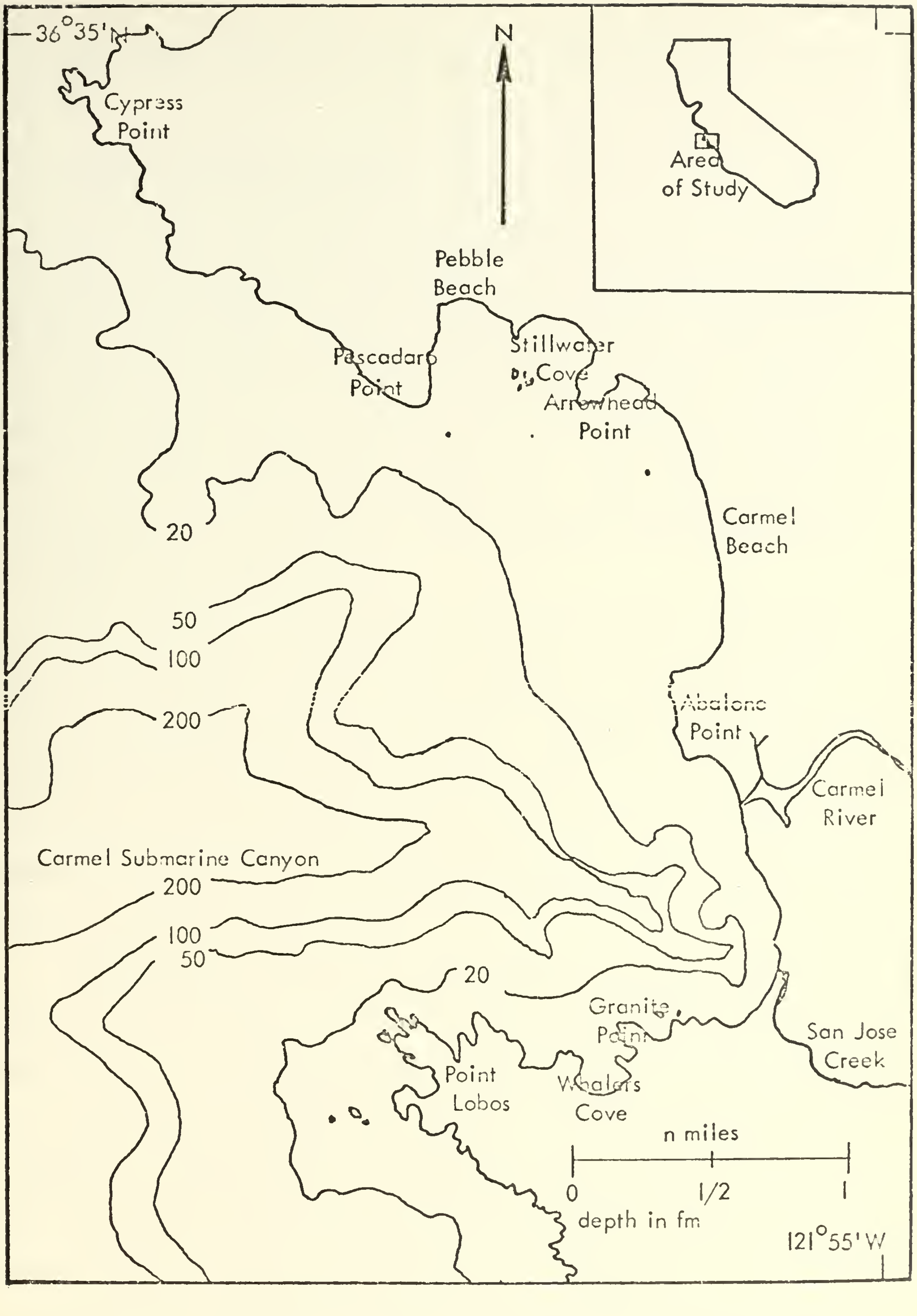

36°35'N
N
Cypress Point
Area of Study
Pebble Beach
Pescadaro Point
Stillwater Cove
Arrowhead Point
Carmel Beach
20
50
100
200
Abalone Point
Carmel River
Carmel Submarine Canyon
200
100
50
20
Granite Point
San Jose Creek
Point Lobos
Whalers Cove
n miles
0
1/2
1
depth in fm
121°55'W

Figure 1. Location Map of Carmel Bay (from C&GS 5476).

are the Carmel River and San Jose Creek, plus some shoreline erosion.

C. PREVIOUS INVESTIGATIONS

Prior to this study, a hydrographic survey of Carmel Bay had been conducted in 1933 by the U.S. Coast and Geodetic Survey (C&GS)(1933). Also, the head of Carmel Canyon had been charted in 1934 by Shepard and Emery (1941). These surveys were conducted using lead line soundings and horizontal sextant angles for positioning. The 1933 survey of C&GS serves as the basis for the present navigation chart of Carmel Bay (C&GS 5476).

The sounding line spacing of the C&GS 1933 survey was 600 ft for depths greater than approximately 20 fm and 300 ft for depths less than 20 fm. Soundings were taken along the lines about every 400 ft in the deeper water and every 200 ft in the shallows. As no more detail than necessary for safe navigation was desired, the deeper areas of the bay lack definition.

The sounding line spacing for the Shepard and Emery survey of the canyon head was 200 ft with soundings taken every 50 ft. This survey was very accurate when accomplished, but this area is subject to variation in depth due to slumping of sediment down the steep canyon walls. It is safe to assume that some bathymetric changes have occurred since 1934.

Lead line soundings give true depths and need only be corrected for tide and wire angles, but suffer from a lack

of continuity. Because lead-line soundings are non-continuous, small-scale features such as rock pinnacles and small channels are difficult to correlate with the overall bottom topography. In addition, wire line soundings cannot be precisely contoured as the depth intervals cannot be accurately interpolated between obtained soundings for areas of rugged and highly variable bathymetry.

II. PROCUREMENT OF DATA

A. SOUNDING LINES

1. Echo-Sounding Equipment

As the ship tracked, 12-kHz fathometer and 3.5-kHz reflection profiling data were taken simultaneously. Both systems utilized 30° transducer cones.

a. Fathometer

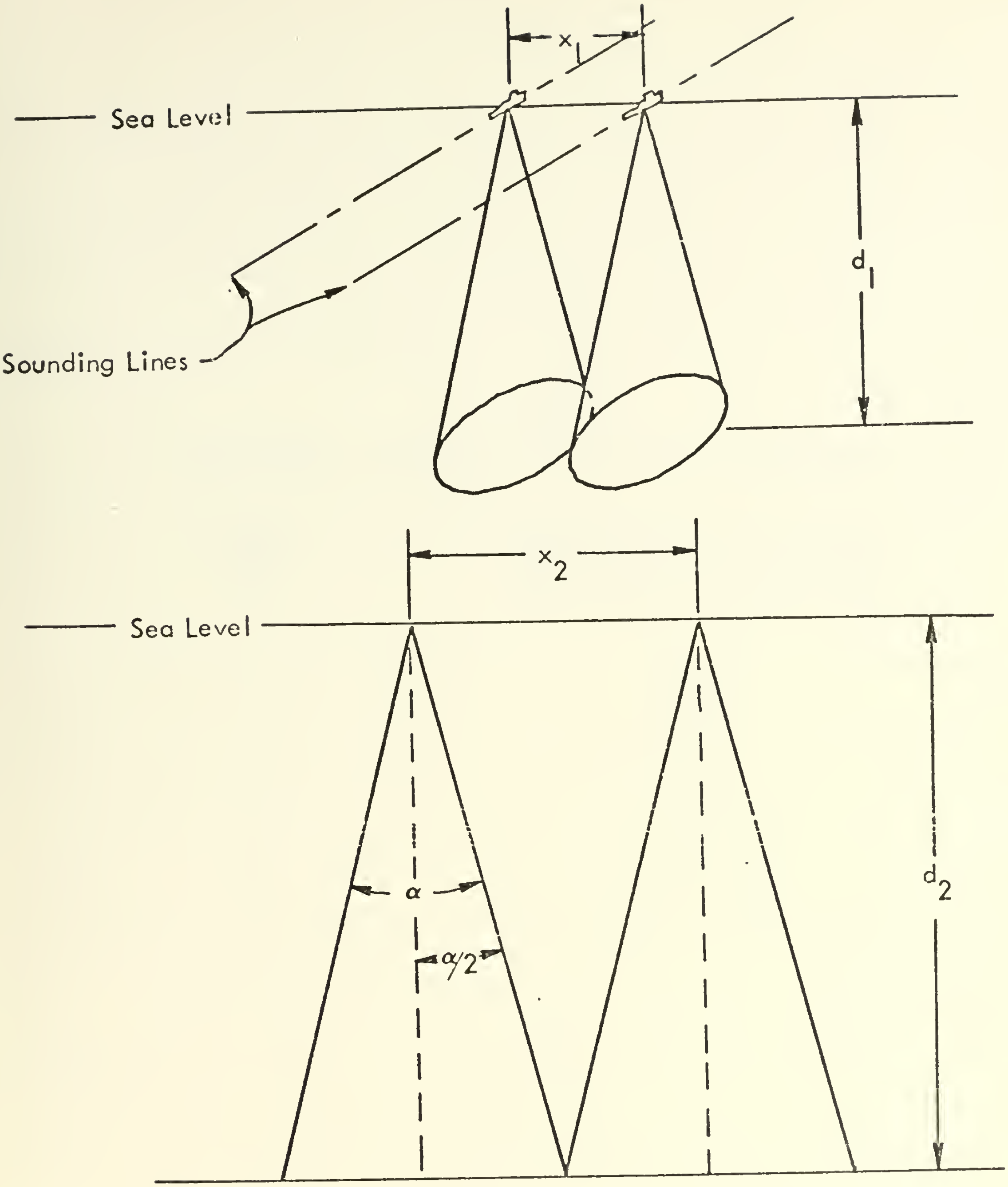
A standard hull-mounted Raytheon 12-kHz ship fathometer was used, the data being recorded on standard 7-inch fathometer recorder paper.

b. 3.5-kHz High Resolution Reflection Profiler

Utilizing a towed streamlined transducer 'fish,' the 3.5-kHz profiling system provided the best bathymetric records of the survey. The record was maintained on a modified Gifft GDR precision depth recorder using 18-inch wide wet paper.

2. Sounding Line Spacing

Optimumly when conducting hydrographic surveys using echo sounders, the incident sound cones of the transducers for parallel adjacent sounding lines should be tangent at the ocean bottom so as to provide 100% coverage of the bottom (Fig. 2). Closer spacing of sounding lines is necessary to obtain this coverage in shallow water due to truncation of the sound cone by the bottom. Some representative sound-line spacings for a 30° cone are shown in Table I.


x_1
Sea Level
d_1
Sounding Lines
x_2
Sea Level
α
$\alpha/2$
d_2

α = angle of transducer sound cone

$\alpha/2$ = half angle of transducer sound cone

d_i = depth

x_i = sounding line spacing for 100% coverage

$x_i = 2d_i \tan(\alpha/2)$

Note: $x_1 < x_2$ for $d_1 < d_2$

Figure 2. Definition of 100% Coverage.

TABLE I

SOUNDING LINE SPACING FOR 100% COVERAGE

Depth fm	Sounding Line Spacing for 100% Coverage, ft
10	32.4
50	161.6
80	258.0
100	323.6
200	649.2

It is estimated that for a hydrographic survey of Carmel Bay to be accomplished with 100% coverage, over 250 n miles of sounding lines would be necessary. This is a large amount considering that Carmel Bay covers less than 6 square miles. The large amount of track is necessary because the northern half of the bay is relatively shallow, requiring a high track density. In addition, the bathymetry of Carmel Bay is very complex, including many rugged rock outcrops on the bottom and a submarine canyon.

Originally proposed sounding line spacings were 250 ft for expected depths less than 80 fm and 500 ft for expected depths greater than 80 fm. These spacings were determined as a compromise between available resources (ship time, navigation net, and acoustic equipment) and desirable track density.

3. Sounding Line Layout

When planning the sounding lines to be steamed in performing a hydrographic survey, the following items were considered:

- Make each line as long as possible to cut down on non-productive time in turns and to provide continuity in the bathymetric records.
- Wider sounding line spacing can be used in deep water without a loss in coverage because the incident sound cone is wider.
- Check-lines should be provided to run at right angles to the tracks to ensure that the depth measurements agree at track intersections.
- Plan sounding lines to run normal to major slope contours so as to avoid cross slope error (discussed in a later section).

The north-south sounding lines of this survey (Fig. 3) were used because they were generally parallel to the major bottom slopes and were the longest tracks possible. These lines were spaced 250 ft apart, with every other north-south sounding line terminated when the expected depth exceeded 80 fm. East-west cross lines were included to check these tracks.

Segmented sounding lines were used around Point Lobos so as to get the maximum resolution of what was known to be an extremely irregular bottom made up primarily of jointed massive igneous rock. The Point Lobos sounding lines were checked with the north-south sounding lines.

4. Sounding Lines Accomplished

The originally planned sounding lines totaled 137 n miles. Due to equipment failure and severe weather limiting the survey to 2½ days of daylight operations, 85 n miles were actually steamed. It is anticipated that the sounding lines not completed will be done at some future date. Figure 3 shows the sounding lines that were steamed and those planned but not completed.

B. NAVIGATION

1. Navigation Equipment

Navigation was accomplished by use of a HIREX positioning system owned and operated by Offshore Navigation, Inc. (ONI), New Orleans, La. Stated accuracy was 5 to 10 ft at ranges of less than 3 miles from the shore stations

APPENDIX B

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 14 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
14	0	0	0.00
14	5	0	5.16
14	10	0	10.31
14	15	0	15.46
14	20	1	20.62
14	25	1	25.77
14	30	1	30.92
14	35	1	36.08
14	40	1	41.23
14	45	1	46.38
14	50	2	51.54
14	55	2	56.69
14	60	2	61.84
14	65	2	66.99
14	70	2	72.15
14	75	2	77.30
14	80	2	82.45
14	85	3	87.61
14	90	3	92.76
14	95	3	97.91
14	100	3	103.07
14	105	3	108.22
14	110	3	113.37
14	115	4	118.53
14	120	4	123.68
14	125	4	128.83
14	130	4	133.98
14	135	4	139.14
14	140	4	144.29
14	145	4	149.44
14	150	5	154.60
14	155	5	159.75
14	160	5	164.90
14	165	5	170.06
14	170	5	175.21
14	175	5	180.36
14	180	6	185.52
14	185	6	190.67
14	190	6	195.82
14	195	6	200.97
14	200	6	206.13
14	205	6	211.28
14	210	6	216.43
14	215	7	221.59
14	220	7	226.74
14	225	7	231.89
14	230	7	237.05
14	235	7	242.20
14	240	7	247.35
14	245	8	252.51
14	250	8	257.66
14	255	8	262.81
14	260	8	267.96
14	265	8	273.12
14	270	8	278.27
14	275	8	283.42
14	280	9	288.58
14	285	9	293.73
14	290	9	298.88
14	295	9	304.04
14	300	9	309.19

APPENDIX B

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 15 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
15	0	0	0.00
15	5	0	5.18
15	10	0	10.36
15	15	1	15.53
15	20	1	20.71
15	25	1	25.89
15	30	1	31.06
15	35	1	36.24
15	40	1	41.42
15	45	2	46.59
15	50	2	51.77
15	55	2	56.95
15	60	2	62.12
15	65	2	67.30
15	70	2	72.47
15	75	3	77.65
15	80	3	82.83
15	85	3	88.00
15	90	3	93.18
15	95	3	98.36
15	100	4	103.53
15	105	4	108.71
15	110	4	113.89
15	115	4	119.06
15	120	4	124.24
15	125	4	129.41
15	130	5	134.59
15	135	5	139.77
15	140	5	144.94
15	145	5	150.12
15	150	5	155.30
15	155	5	160.47
15	160	6	165.65
15	165	6	170.83
15	170	6	176.00
15	175	6	181.18
15	180	6	186.35
15	185	7	191.53
15	190	7	196.71
15	195	7	201.88
15	200	7	207.06
15	205	7	212.24
15	210	7	217.41
15	215	8	222.59
15	220	8	227.77
15	225	8	232.94
15	230	8	238.12
15	235	8	243.29
15	240	8	248.47
15	245	9	253.65
15	250	9	258.82
15	255	9	264.00
15	260	9	269.18
15	265	9	274.35
15	270	10	279.53
15	275	10	284.71
15	280	10	289.88
15	285	10	295.06
15	290	10	300.23
15	295	10	305.41
15	300	11	310.59

```
C
C
C
C
C                        APPENDIX C
C
C               CORRECTIONS FOR TRUE BOTTOM SLOPES
C               GREATER THAN 15 DEGREES
C
C
C
C
C
      K=15
      THETA=0.26180
 0003 R=-5.0
      WRITE(6,98)
   98 FORMAT('1',///)
      WRITE(6,99)
   99 FORMAT(' ',24X,'APPENDIX C',/)
      WRITE(6,102)K
  102 FORMAT(' ',9X,'DEPTH CORRECTIONS FOR A TRUE SLOPE OF '
     X,I2,' DEGREES',/////)
      WRITE(6,100)
  100 FORMAT(' ',10X,'TRUE SLOPE',3X,'ECHO DEPTH',2X,
     X'INCREASE',2X,'TRUE DEPTH')
      WRITE(6,101)
  101 FORMAT(' ',11X,'(DEGREES)',4X,'(FATHOMS)',3X,
     X'(FATHOMS)',2X,'(FATHOMS)',//)
 0002 R=R+5.0
      Z=R*(0.96593+0.25882*(TAN(THETA)))
      N=Z+0.5-R
      L=R
      WRITE(6,200)K,L,N,Z
  200 FORMAT(' ',14X,I2,10X,I3,10X,I2,7X,F6.2)
      IF(R.LT.300) GO TO 2
      IF(K.GT.50) GO TO 1
      R=-5.0
      THETA=THETA+0.017453
      K=K+1
      GO TO 3
 0001 STOP
      END
```

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 15 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
15	0	0	0.0
15	5	0	5.18
15	10	0	10.35
15	15	1	15.53
15	20	1	20.71
15	25	1	25.88
15	30	1	31.06
15	35	1	36.23
15	40	1	41.41
15	45	2	46.59
15	50	2	51.76
15	55	2	56.94
15	60	2	62.12
15	65	2	67.29
15	70	2	72.47
15	75	3	77.65
15	80	3	82.82
15	85	3	88.00
15	90	3	93.18
15	95	3	98.35
15	100	4	103.53
15	105	4	108.70
15	110	4	113.88
15	115	4	119.06
15	120	4	124.23
15	125	4	129.41
15	130	5	134.59
15	135	5	139.76
15	140	5	144.94
15	145	5	150.12
15	150	5	155.29
15	155	5	160.47
15	160	6	165.64
15	165	6	170.82
15	170	6	176.00
15	175	6	181.17
15	180	6	186.35
15	185	7	191.53
15	190	7	196.70
15	195	7	201.88
15	200	7	207.06
15	205	7	212.23
15	210	7	217.41
15	215	8	222.59
15	220	8	227.76
15	225	8	232.94
15	230	8	238.11
15	235	8	243.29
15	240	8	248.47
15	245	9	253.64
15	250	9	258.82
15	255	9	264.00
15	260	9	269.17
15	265	9	274.35
15	270	10	279.53
15	275	10	284.70
15	280	10	289.88
15	285	10	295.05
15	290	10	300.23
15	295	10	305.41
15	300	11	310.58

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 16 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
16	0	0	0.0
16	5	0	5.20
16	10	0	10.40
16	15	1	15.60
16	20	1	20.80
16	25	1	26.00
16	30	1	31.20
16	35	1	36.41
16	40	2	41.61
16	45	2	46.81
16	50	2	52.01
16	55	2	57.21
16	60	2	62.41
16	65	3	67.61
16	70	3	72.81
16	75	3	78.01
16	80	3	83.21
16	85	3	88.41
16	90	4	93.61
16	95	4	98.81
16	100	4	104.01
16	105	4	109.22
16	110	4	114.42
16	115	5	119.62
16	120	5	124.82
16	125	5	130.02
16	130	5	135.22
16	135	5	140.42
16	140	6	145.62
16	145	6	150.82
16	150	6	156.02
16	155	6	161.22
16	160	6	166.42
16	165	7	171.62
16	170	7	176.82
16	175	7	182.03
16	180	7	187.23
16	185	7	192.43
16	190	8	197.63
16	195	8	202.83
16	200	8	208.03
16	205	8	213.23
16	210	8	218.43
16	215	9	223.63
16	220	9	228.83
16	225	9	234.03
16	230	9	239.23
16	235	9	244.43
16	240	10	249.63
16	245	10	254.84
16	250	10	260.04
16	255	10	265.24
16	260	10	270.44
16	265	11	275.64
16	270	11	280.84
16	275	11	286.04
16	280	11	291.24
16	285	11	296.44
16	290	12	301.64
16	295	12	306.84
16	300	12	312.04

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 17 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
17	0	0	0.0
17	5	0	5.23
17	10	0	10.45
17	15	1	15.68
17	20	1	20.90
17	25	1	26.13
17	30	1	31.35
17	35	2	36.58
17	40	2	41.80
17	45	2	47.03
17	50	2	52.25
17	55	2	57.48
17	60	3	62.70
17	65	3	67.93
17	70	3	73.15
17	75	3	78.38
17	80	4	83.60
17	85	4	88.83
17	90	4	94.06
17	95	4	99.28
17	100	5	104.51
17	105	5	109.73
17	110	5	114.96
17	115	5	120.18
17	120	5	125.41
17	125	6	130.63
17	130	6	135.86
17	135	6	141.08
17	140	6	146.31
17	145	7	151.53
17	150	7	156.76
17	155	7	161.98
17	160	7	167.21
17	165	7	172.43
17	170	8	177.66
17	175	8	182.89
17	180	8	188.11
17	185	8	193.34
17	190	9	198.56
17	195	9	203.79
17	200	9	209.01
17	205	9	214.24
17	210	9	219.46
17	215	10	224.69
17	220	10	229.91
17	225	10	235.14
17	230	10	240.36
17	235	11	245.59
17	240	11	250.81
17	245	11	256.04
17	250	11	261.26
17	255	11	266.49
17	260	12	271.72
17	265	12	276.94
17	270	12	282.17
17	275	12	287.39
17	280	13	292.62
17	285	13	297.84
17	290	13	303.07
17	295	13	308.29
17	300	14	313.52

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 18 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
18	0	0	0.0
18	5	0	5.25
18	10	1	10.50
18	15	1	15.75
18	20	1	21.00
18	25	1	26.25
18	30	2	31.50
18	35	2	36.75
18	40	2	42.00
18	45	2	47.25
18	50	3	52.50
18	55	3	57.75
18	60	3	63.00
18	65	3	68.25
18	70	4	73.50
18	75	4	78.75
18	80	4	84.00
18	85	4	89.25
18	90	5	94.50
18	95	5	99.75
18	100	5	105.00
18	105	5	110.25
18	110	6	115.50
18	115	6	120.75
18	120	6	126.00
18	125	6	131.25
18	130	7	136.50
18	135	7	141.75
18	140	7	147.00
18	145	7	152.25
18	150	8	157.50
18	155	8	162.75
18	160	8	168.00
18	165	8	173.25
18	170	9	178.50
18	175	9	183.75
18	180	9	189.00
18	185	9	194.25
18	190	10	199.50
18	195	10	204.75
18	200	10	210.00
18	205	10	215.26
18	210	11	220.51
18	215	11	225.76
18	220	11	231.01
18	225	11	236.26
18	230	12	241.51
18	235	12	246.76
18	240	12	252.01
18	245	12	257.26
18	250	13	262.51
18	255	13	267.76
18	260	13	273.01
18	265	13	278.26
18	270	14	283.51
18	275	14	288.76
18	280	14	294.01
18	285	14	299.26
18	290	15	304.51
18	295	15	309.76
18	300	15	315.01

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 19 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
19	0	0	0.0
19	5	0	5.28
19	10	1	10.55
19	15	1	15.83
19	20	1	21.10
19	25	1	26.38
19	30	2	31.65
19	35	2	36.93
19	40	2	42.20
19	45	2	47.48
19	50	3	52.75
19	55	3	58.03
19	60	3	63.30
19	65	4	68.58
19	70	4	73.85
19	75	4	79.13
19	80	4	84.40
19	85	5	89.68
19	90	5	94.95
19	95	5	100.23
19	100	6	105.50
19	105	6	110.78
19	110	6	116.06
19	115	6	121.33
19	120	7	126.61
19	125	7	131.88
19	130	7	137.16
19	135	7	142.43
19	140	8	147.71
19	145	8	152.98
19	150	8	158.26
19	155	9	163.53
19	160	9	168.81
19	165	9	174.08
19	170	9	179.36
19	175	10	184.63
19	180	10	189.91
19	185	10	195.18
19	190	10	200.46
19	195	11	205.73
19	200	11	211.01
19	205	11	216.28
19	210	12	221.56
19	215	12	226.84
19	220	12	232.11
19	225	12	237.39
19	230	13	242.66
19	235	13	247.94
19	240	13	253.21
19	245	13	258.49
19	250	14	263.76
19	255	14	269.04
19	260	14	274.31
19	265	15	279.59
19	270	15	284.86
19	275	15	290.14
19	280	15	295.41
19	285	16	300.69
19	290	16	305.96
19	295	16	311.24
19	300	17	316.51

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 20 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
20	0	0	0.0
20	5	0	5.30
20	10	1	10.60
20	15	1	15.90
20	20	1	21.20
20	25	2	26.50
20	30	2	31.80
20	35	2	37.10
20	40	2	42.41
20	45	3	47.71
20	50	3	53.01
20	55	3	58.31
20	60	4	63.61
20	65	4	68.91
20	70	4	74.21
20	75	5	79.51
20	80	5	84.81
20	85	5	90.11
20	90	5	95.41
20	95	6	100.71
20	100	6	106.01
20	105	6	111.31
20	110	7	116.61
20	115	7	121.92
20	120	7	127.22
20	125	8	132.52
20	130	8	137.82
20	135	8	143.12
20	140	8	148.42
20	145	9	153.72
20	150	9	159.02
20	155	9	164.32
20	160	10	169.62
20	165	10	174.92
20	170	10	180.22
20	175	11	185.52
20	180	11	190.82
20	185	11	196.12
20	190	11	201.43
20	195	12	206.73
20	200	12	212.03
20	205	12	217.33
20	210	13	222.63
20	215	13	227.93
20	220	13	233.23
20	225	14	238.53
20	230	14	243.83
20	235	14	249.13
20	240	14	254.43
20	245	15	259.73
20	250	15	265.03
20	255	15	270.33
20	260	16	275.63
20	265	16	280.93
20	270	16	286.24
20	275	17	291.54
20	280	17	296.84
20	285	17	302.14
20	290	17	307.44
20	295	18	312.74
20	300	18	318.04

APPENDIX C

DEPTH CORRECTICNS FOR A TRUE SLOPE OF 21 DEGREES

TRUE SLOPE (DEGREES)	ECHC DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
21	0	0	0.0
21	5	0	5.33
21	10	1	10.65
21	15	1	15.98
21	20	1	21.31
21	25	2	26.63
21	30	2	31.96
21	35	2	37.28
21	40	3	42.61
21	45	3	47.94
21	50	3	53.26
21	55	4	58.59
21	60	4	63.92
21	65	4	69.24
21	70	5	74.57
21	75	5	79.90
21	80	5	85.22
21	85	6	90.55
21	90	6	95.88
21	95	6	101.20
21	100	7	106.53
21	105	7	111.85
21	110	7	117.18
21	115	8	122.51
21	120	8	127.83
21	125	8	133.16
21	130	8	138.49
21	135	9	143.81
21	140	9	149.14
21	145	9	154.47
21	150	10	159.79
21	155	10	165.12
21	160	10	170.44
21	165	11	175.77
21	170	11	181.10
21	175	11	186.42
21	180	12	191.75
21	185	12	197.08
21	190	12	202.40
21	195	13	207.73
21	200	13	213.06
21	205	13	218.38
21	210	14	223.71
21	215	14	229.04
21	220	14	234.36
21	225	15	239.69
21	230	15	245.01
21	235	15	250.34
21	240	16	255.67
21	245	16	260.99
21	250	16	266.32
21	255	17	271.65
21	260	17	276.97
21	265	17	282.30
21	270	18	287.63
21	275	18	292.95
21	280	18	298.28
21	285	19	303.60
21	290	19	308.93
21	295	19	314.26
21	300	20	319.58

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 22 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
22	0	0	0.0
22	5	0	5.35
22	10	1	10.70
22	15	1	16.06
22	20	1	21.41
22	25	2	26.76
22	30	2	32.11
22	35	2	37.47
22	40	3	42.82
22	45	3	48.17
22	50	4	53.52
22	55	4	58.88
22	60	4	64.23
22	65	5	69.58
22	70	5	74.93
22	75	5	80.29
22	80	6	85.64
22	85	6	90.99
22	90	6	96.34
22	95	7	101.70
22	100	7	107.05
22	105	7	112.40
22	110	8	117.75
22	115	8	123.11
22	120	8	128.46
22	125	9	133.81
22	130	9	139.16
22	135	10	144.52
22	140	10	149.87
22	145	10	155.22
22	150	11	160.57
22	155	11	165.93
22	160	11	171.28
22	165	12	176.63
22	170	12	181.98
22	175	12	187.34
22	180	13	192.69
22	185	13	198.04
22	190	13	203.39
22	195	14	208.75
22	200	14	214.10
22	205	14	219.45
22	210	15	224.80
22	215	15	230.16
22	220	16	235.51
22	225	16	240.86
22	230	16	246.21
22	235	17	251.57
22	240	17	256.92
22	245	17	262.27
22	250	18	267.62
22	255	18	272.98
22	260	18	278.33
22	265	19	283.68
22	270	19	289.03
22	275	19	294.39
22	280	20	299.74
22	285	20	305.09
22	290	20	310.44
22	295	21	315.80
22	300	21	321.15

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 25 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
25	0	0	0.0
25	5	0	5.43
25	10	1	10.87
25	15	1	16.30
25	20	2	21.73
25	25	2	27.17
25	30	3	32.60
25	35	3	38.03
25	40	3	43.46
25	45	4	48.90
25	50	4	54.33
25	55	5	59.76
25	60	5	65.20
25	65	6	70.63
25	70	6	76.06
25	75	6	81.50
25	80	7	86.93
25	85	7	92.36
25	90	8	97.80
25	95	8	103.23
25	100	9	108.66
25	105	9	114.09
25	110	10	119.53
25	115	10	124.96
25	120	10	130.39
25	125	11	135.83
25	130	11	141.26
25	135	12	146.69
25	140	12	152.13
25	145	13	157.56
25	150	13	162.99
25	155	13	168.43
25	160	14	173.86
25	165	14	179.29
25	170	15	184.73
25	175	15	190.16
25	180	16	195.59
25	185	16	201.02
25	190	16	206.46
25	195	17	211.89
25	200	17	217.32
25	205	18	222.76
25	210	18	228.19
25	215	19	233.62
25	220	19	239.06
25	225	19	244.49
25	230	20	249.92
25	235	20	255.36
25	240	21	260.79
25	245	21	266.22
25	250	22	271.65
25	255	22	277.09
25	260	23	282.52
25	265	23	287.95
25	270	23	293.39
25	275	24	298.82
25	280	24	304.25
25	285	25	309.69
25	290	25	315.12
25	295	26	320.55
25	300	26	325.99

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 26 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
26	0	0	0.0
26	5	0	5.46
26	10	1	10.92
26	15	1	16.38
26	20	2	21.84
26	25	2	27.30
26	30	3	32.76
26	35	3	38.23
26	40	4	43.69
26	45	4	49.15
26	50	5	54.61
26	55	5	60.07
26	60	6	65.53
26	65	6	70.99
26	70	6	76.45
26	75	7	81.91
26	80	7	87.37
26	85	8	92.83
26	90	8	98.29
26	95	9	103.76
26	100	9	109.22
26	105	10	114.68
26	110	10	120.14
26	115	11	125.60
26	120	11	131.06
26	125	12	136.52
26	130	12	141.98
26	135	12	147.44
26	140	13	152.90
26	145	13	158.36
26	150	14	163.82
26	155	14	169.29
26	160	15	174.75
26	165	15	180.21
26	170	16	185.67
26	175	16	191.13
26	180	17	196.59
26	185	17	202.05
26	190	18	207.51
26	195	18	212.97
26	200	18	218.43
26	205	19	223.89
26	210	19	229.35
26	215	20	234.82
26	220	20	240.28
26	225	21	245.74
26	230	21	251.20
26	235	22	256.66
26	240	22	262.12
26	245	23	267.58
26	250	23	273.04
26	255	24	278.50
26	260	24	283.96
26	265	24	289.42
26	270	25	294.88
26	275	25	300.34
26	280	26	305.81
26	285	26	311.27
26	290	27	316.73
26	295	27	322.19
26	300	28	327.65

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 27 DEGREES

TRUE SLOPE (DEGREES)	ECHC DEPTH (FATHOMS)	INCREASE (FATHCMS)	TRUE DEPTH (FATHOMS)
27	0	0	0.0
27	5	0	5.49
27	10	1	10.98
27	15	1	16.47
27	20	2	21.96
27	25	2	27.45
27	30	3	32.93
27	35	3	38.42
27	40	4	43.91
27	45	4	49.40
27	50	5	54.89
27	55	5	60.38
27	60	6	65.87
27	65	6	71.36
27	70	7	76.85
27	75	7	82.34
27	80	8	87.82
27	85	8	93.31
27	90	9	98.80
27	95	9	104.29
27	100	10	109.78
27	105	10	115.27
27	110	11	120.76
27	115	11	126.25
27	120	12	131.74
27	125	12	137.23
27	130	13	142.71
27	135	13	148.20
27	140	14	153.69
27	145	14	159.18
27	150	15	164.67
27	155	15	170.16
27	160	16	175.65
27	165	16	181.14
27	170	17	186.63
27	175	17	192.12
27	180	18	197.60
27	185	18	203.09
27	190	19	208.58
27	195	19	214.07
27	200	20	219.56
27	205	20	225.05
27	210	21	230.54
27	215	21	236.03
27	220	22	241.52
27	225	22	247.01
27	230	22	252.49
27	235	23	257.98
27	240	23	263.47
27	245	24	268.96
27	250	24	274.45
27	255	25	279.94
27	260	25	285.43
27	265	26	290.92
27	270	26	296.41
27	275	27	301.90
27	280	27	307.39
27	285	28	312.87
27	290	28	318.36
27	295	29	323.85
27	300	29	329.34

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 29 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
29	0	0	0.0
29	5	1	5.55
29	10	1	11.09
29	15	2	16.64
29	20	2	22.19
29	25	3	27.73
29	30	3	33.28
29	35	4	38.83
29	40	4	44.38
29	45	5	49.92
29	50	5	55.47
29	55	6	61.02
29	60	7	66.56
29	65	7	72.11
29	70	8	77.66
29	75	8	83.20
29	80	9	88.75
29	85	9	94.30
29	90	10	99.85
29	95	10	105.39
29	100	11	110.94
29	105	11	116.49
29	110	12	122.03
29	115	13	127.58
29	120	13	133.13
29	125	14	138.67
29	130	14	144.22
29	135	15	149.77
29	140	15	155.32
29	145	16	160.86
29	150	16	166.41
29	155	17	171.96
29	160	18	177.50
29	165	18	183.05
29	170	19	188.60
29	175	19	194.14
29	180	20	199.69
29	185	20	205.24
29	190	21	210.78
29	195	21	216.33
29	200	22	221.88
29	205	22	227.43
29	210	23	232.97
29	215	24	238.52
29	220	24	244.07
29	225	25	249.61
29	230	25	255.16
29	235	26	260.71
29	240	26	266.25
29	245	27	271.80
29	250	27	277.35
29	255	28	282.90
29	260	28	288.44
29	265	29	293.99
29	270	30	299.54
29	275	30	305.08
29	280	31	310.63
29	285	31	316.18
29	290	32	321.72
29	295	32	327.27
29	300	33	332.82

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 30 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
30	0	0	0.0
30	5	1	5.58
30	10	1	11.15
30	15	2	16.73
30	20	2	22.31
30	25	3	27.88
30	30	3	33.46
30	35	4	39.04
30	40	5	44.61
30	45	5	50.19
30	50	6	55.77
30	55	6	61.34
30	60	7	66.92
30	65	7	72.50
30	70	8	78.08
30	75	9	83.65
30	80	9	89.23
30	85	10	94.81
30	90	10	100.38
30	95	11	105.96
30	100	12	111.54
30	105	12	117.11
30	110	13	122.69
30	115	13	128.27
30	120	14	133.84
30	125	14	139.42
30	130	15	145.00
30	135	16	150.57
30	140	16	156.15
30	145	17	161.73
30	150	17	167.30
30	155	18	172.88
30	160	18	178.46
30	165	19	184.03
30	170	20	189.61
30	175	20	195.19
30	180	21	200.76
30	185	21	206.34
30	190	22	211.92
30	195	22	217.49
30	200	23	223.07
30	205	24	228.65
30	210	24	234.23
30	215	25	239.80
30	220	25	245.38
30	225	26	250.96
30	230	27	256.53
30	235	27	262.11
30	240	28	267.69
30	245	28	273.26
30	250	29	278.84
30	255	29	284.42
30	260	30	289.99
30	265	31	295.57
30	270	31	301.15
30	275	32	306.72
30	280	32	312.30
30	285	33	317.88
30	290	33	323.45
30	295	34	329.03
30	300	35	334.61

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 31 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
31	0	0	0.0
31	5	1	5.61
31	10	1	11.21
31	15	2	16.82
31	20	2	22.43
31	25	3	28.04
31	30	4	33.64
31	35	4	39.25
31	40	5	44.86
31	45	5	50.46
31	50	6	56.07
31	55	7	61.68
31	60	7	67.29
31	65	8	72.89
31	70	9	78.50
31	75	9	84.11
31	80	10	89.72
31	85	10	95.32
31	90	11	100.93
31	95	12	106.54
31	100	12	112.14
31	105	13	117.75
31	110	13	123.36
31	115	14	128.97
31	120	15	134.57
31	125	15	140.18
31	130	16	145.79
31	135	16	151.39
31	140	17	157.00
31	145	18	162.61
31	150	18	168.22
31	155	19	173.82
31	160	19	179.43
31	165	20	185.04
31	170	21	190.65
31	175	21	196.25
31	180	22	201.86
31	185	22	207.47
31	190	23	213.07
31	195	24	218.68
31	200	24	224.29
31	205	25	229.90
31	210	26	235.50
31	215	26	241.11
31	220	27	246.72
31	225	27	252.32
31	230	28	257.93
31	235	29	263.54
31	240	29	269.15
31	245	30	274.75
31	250	30	280.36
31	255	31	285.97
31	260	32	291.57
31	265	32	297.18
31	270	33	302.79
31	275	33	308.40
31	280	34	314.00
31	285	35	319.61
31	290	35	325.22
31	295	36	330.83
31	300	36	336.43

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 32 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
32	0	0	0.0
32	5	1	5.64
32	10	1	11.28
32	15	2	16.91
32	20	3	22.55
32	25	3	28.19
32	30	4	33.83
32	35	4	39.47
32	40	5	45.11
32	45	6	50.74
32	50	6	56.38
32	55	7	62.02
32	60	8	67.66
32	65	8	73.30
32	70	9	78.94
32	75	10	84.57
32	80	10	90.21
32	85	11	95.85
32	90	11	101.49
32	95	12	107.13
32	100	13	112.77
32	105	13	118.40
32	110	14	124.04
32	115	15	129.68
32	120	15	135.32
32	125	16	140.96
32	130	17	146.60
32	135	17	152.23
32	140	18	157.87
32	145	19	163.51
32	150	19	169.15
32	155	20	174.79
32	160	20	180.42
32	165	21	186.06
32	170	22	191.70
32	175	22	197.34
32	180	23	202.98
32	185	24	208.62
32	190	24	214.25
32	195	25	219.89
32	200	26	225.53
32	205	26	231.17
32	210	27	236.81
32	215	27	242.45
32	220	28	248.08
32	225	29	253.72
32	230	29	259.36
32	235	30	265.00
32	240	31	270.64
32	245	31	276.28
32	250	32	281.91
32	255	33	287.55
32	260	33	293.19
32	265	34	298.83
32	270	34	304.47
32	275	35	310.11
32	280	36	315.74
32	285	36	321.38
32	290	37	327.02
32	295	38	332.66
32	300	38	338.30

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 33 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
33	0	0	0.0
33	5	1	5.67
33	10	1	11.34
33	15	2	17.01
33	20	3	22.68
33	25	3	28.35
33	30	4	34.02
33	35	5	39.69
33	40	5	45.36
33	45	6	51.03
33	50	7	56.70
33	55	7	62.37
33	60	8	68.04
33	65	9	73.71
33	70	9	79.38
33	75	10	85.05
33	80	11	90.72
33	85	11	96.39
33	90	12	102.06
33	95	13	107.73
33	100	13	113.40
33	105	14	119.07
33	110	15	124.74
33	115	15	130.41
33	120	16	136.08
33	125	17	141.75
33	130	17	147.42
33	135	18	153.09
33	140	19	158.76
33	145	19	164.43
33	150	20	170.10
33	155	21	175.77
33	160	21	181.44
33	165	22	187.11
33	170	23	192.78
33	175	23	198.45
33	180	24	204.12
33	185	25	209.79
33	190	25	215.46
33	195	26	221.13
33	200	27	226.80
33	205	27	232.47
33	210	28	238.14
33	215	29	243.81
33	220	29	249.48
33	225	30	255.15
33	230	31	260.82
33	235	31	266.49
33	240	32	272.16
33	245	33	277.83
33	250	34	283.50
33	255	34	289.17
33	260	35	294.84
33	265	36	300.51
33	270	36	306.18
33	275	37	311.85
33	280	38	317.52
33	285	38	323.19
33	290	39	328.86
33	295	40	334.53
33	300	40	340.20

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 34 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
34	0	0	0.0
34	5	1	5.70
34	10	1	11.41
34	15	2	17.11
34	20	3	22.81
34	25	4	28.51
34	30	4	34.22
34	35	5	39.92
34	40	6	45.62
34	45	6	51.32
34	50	7	57.03
34	55	8	62.73
34	60	8	68.43
34	65	9	74.13
34	70	10	79.84
34	75	11	85.54
34	80	11	91.24
34	85	12	96.94
34	90	13	102.65
34	95	13	108.35
34	100	14	114.05
34	105	15	119.75
34	110	15	125.46
34	115	16	131.16
34	120	17	136.86
34	125	18	142.56
34	130	18	148.27
34	135	19	153.97
34	140	20	159.67
34	145	20	165.37
34	150	21	171.08
34	155	22	176.78
34	160	22	182.48
34	165	23	188.18
34	170	24	193.89
34	175	25	199.59
34	180	25	205.29
34	185	26	210.99
34	190	27	216.70
34	195	27	222.40
34	200	28	228.10
34	205	29	233.80
34	210	30	239.51
34	215	30	245.21
34	220	31	250.91
34	225	32	256.61
34	230	32	262.32
34	235	33	268.02
34	240	34	273.72
34	245	34	279.42
34	250	35	285.13
34	255	36	290.83
34	260	37	296.53
34	265	37	302.23
34	270	38	307.94
34	275	39	313.64
34	280	39	319.34
34	285	40	325.04
34	290	41	330.75
34	295	41	336.45
34	300	42	342.15

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 35 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
35	0	0	0.0
35	5	1	5.74
35	10	1	11.47
35	15	2	17.21
35	20	3	22.94
35	25	4	28.68
35	30	4	34.41
35	35	5	40.15
35	40	6	45.89
35	45	7	51.62
35	50	7	57.36
35	55	8	63.09
35	60	9	68.83
35	65	10	74.57
35	70	10	80.30
35	75	11	86.04
35	80	12	91.77
35	85	13	97.51
35	90	13	103.24
35	95	14	108.98
35	100	15	114.72
35	105	15	120.45
35	110	16	126.19
35	115	17	131.92
35	120	18	137.66
35	125	18	143.39
35	130	19	149.13
35	135	20	154.87
35	140	21	160.60
35	145	21	166.34
35	150	22	172.07
35	155	23	177.81
35	160	24	183.54
35	165	24	189.28
35	170	25	195.02
35	175	26	200.75
35	180	26	206.49
35	185	27	212.22
35	190	28	217.96
35	195	29	223.70
35	200	29	229.43
35	205	30	235.17
35	210	31	240.90
35	215	32	246.64
35	220	32	252.37
35	225	33	258.11
35	230	34	263.85
35	235	35	269.58
35	240	35	275.32
35	245	36	281.05
35	250	37	286.79
35	255	38	292.52
35	260	38	298.26
35	265	39	304.00
35	270	40	309.73
35	275	40	315.47
35	280	41	321.20
35	285	42	326.94
35	290	43	332.67
35	295	43	338.41
35	300	44	344.15

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 36 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
36	0	0	0.0
36	5	1	5.77
36	10	2	11.54
36	15	2	17.31
36	20	3	23.08
36	25	4	28.85
36	30	5	34.62
36	35	5	40.39
36	40	6	46.16
36	45	7	51.93
36	50	8	57.70
36	55	8	63.47
36	60	9	69.24
36	65	10	75.01
36	70	11	80.78
36	75	12	86.55
36	80	12	92.32
36	85	13	98.09
36	90	14	103.86
36	95	15	109.63
36	100	15	115.40
36	105	16	121.17
36	110	17	126.94
36	115	18	132.71
36	120	18	138.48
36	125	19	144.25
36	130	20	150.02
36	135	21	155.79
36	140	22	161.56
36	145	22	167.33
36	150	23	173.10
36	155	24	178.87
36	160	25	184.64
36	165	25	190.41
36	170	26	196.18
36	175	27	201.94
36	180	28	207.71
36	185	28	213.48
36	190	29	219.25
36	195	30	225.02
36	200	31	230.79
36	205	32	236.56
36	210	32	242.33
36	215	33	248.10
36	220	34	253.87
36	225	35	259.64
36	230	35	265.41
36	235	36	271.18
36	240	37	276.95
36	245	38	282.72
36	250	38	288.49
36	255	39	294.26
36	260	40	300.03
36	265	41	305.80
36	270	42	311.57
36	275	42	317.34
36	280	43	323.11
36	285	44	328.88
36	290	45	334.65
36	295	45	340.42
36	300	46	346.19

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 37 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
37	0	0	0.0
37	5	1	5.80
37	10	2	11.61
37	15	2	17.41
37	20	3	23.22
37	25	4	29.02
37	30	5	34.83
37	35	6	40.63
37	40	6	46.44
37	45	7	52.24
37	50	8	58.05
37	55	9	63.85
37	60	10	69.66
37	65	10	75.46
37	70	11	81.27
37	75	12	87.07
37	80	13	92.88
37	85	14	98.68
37	90	14	104.49
37	95	15	110.29
37	100	16	116.10
37	105	17	121.90
37	110	18	127.71
37	115	19	133.51
37	120	19	139.32
37	125	20	145.12
37	130	21	150.92
37	135	22	156.73
37	140	23	162.53
37	145	23	168.34
37	150	24	174.14
37	155	25	179.95
37	160	26	185.75
37	165	27	191.56
37	170	27	197.36
37	175	28	203.17
37	180	29	208.97
37	185	30	214.78
37	190	31	220.58
37	195	31	226.39
37	200	32	232.19
37	205	33	238.00
37	210	34	243.80
37	215	35	249.61
37	220	35	255.41
37	225	36	261.22
37	230	37	267.02
37	235	38	272.83
37	240	39	278.63
37	245	39	284.44
37	250	40	290.24
37	255	41	296.04
37	260	42	301.85
37	265	43	307.65
37	270	43	313.46
37	275	44	319.26
37	280	45	325.07
37	285	46	330.87
37	290	47	336.68
37	295	47	342.48
37	300	48	348.29

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 38 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
38	0	0	0.0
38	5	1	5.84
38	10	2	11.68
38	15	3	17.52
38	20	3	23.36
38	25	4	29.20
38	30	5	35.04
38	35	6	40.88
38	40	7	46.73
38	45	8	52.57
38	50	8	58.41
38	55	9	64.25
38	60	10	70.09
38	65	11	75.93
38	70	12	81.77
38	75	13	87.61
38	80	13	93.45
38	85	14	99.29
38	90	15	105.13
38	95	16	110.97
38	100	17	116.81
38	105	18	122.65
38	110	18	128.50
38	115	19	134.34
38	120	20	140.18
38	125	21	146.02
38	130	22	151.86
38	135	23	157.70
38	140	24	163.54
38	145	24	169.38
38	150	25	175.22
38	155	26	181.06
38	160	27	186.90
38	165	28	192.74
38	170	29	198.58
38	175	29	204.42
38	180	30	210.26
38	185	31	216.11
38	190	32	221.95
38	195	33	227.79
38	200	34	233.63
38	205	34	239.47
38	210	35	245.31
38	215	36	251.15
38	220	37	256.99
38	225	38	262.83
38	230	39	268.67
38	235	40	274.51
38	240	40	280.35
38	245	41	286.19
38	250	42	292.03
38	255	43	297.88
38	260	44	303.72
38	265	45	309.56
38	270	45	315.40
38	275	46	321.24
38	280	47	327.08
38	285	48	332.92
38	290	49	338.76
38	295	50	344.60
38	300	50	350.44

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 39 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
39	0	0	0.0
39	5	1	5.88
39	10	2	11.76
39	15	3	17.63
39	20	4	23.51
39	25	4	29.39
39	30	5	35.27
39	35	6	41.14
39	40	7	47.02
39	45	8	52.90
39	50	9	58.78
39	55	10	64.65
39	60	11	70.53
39	65	11	76.41
39	70	12	82.29
39	75	13	88.16
39	80	14	94.04
39	85	15	99.92
39	90	16	105.80
39	95	17	111.67
39	100	18	117.55
39	105	18	123.43
39	110	19	129.31
39	115	20	135.18
39	120	21	141.06
39	125	22	146.94
39	130	23	152.82
39	135	24	158.69
39	140	25	164.57
39	145	25	170.45
39	150	26	176.33
39	155	27	182.20
39	160	28	188.08
39	165	29	193.96
39	170	30	199.84
39	175	31	205.71
39	180	32	211.59
39	185	32	217.47
39	190	33	223.35
39	195	34	229.23
39	200	35	235.10
39	205	36	240.98
39	210	37	246.86
39	215	38	252.74
39	220	39	258.61
39	225	39	264.49
39	230	40	270.37
39	235	41	276.25
39	240	42	282.12
39	245	43	288.00
39	250	44	293.88
39	255	45	299.76
39	260	46	305.63
39	265	47	311.51
39	270	47	317.39
39	275	48	323.27
39	280	49	329.14
39	285	50	335.02
39	290	51	340.90
39	295	52	346.78
39	300	53	352.65

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 40 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
40	0	0	0.0
40	5	1	5.92
40	10	2	11.83
40	15	3	17.75
40	20	4	23.66
40	25	5	29.58
40	30	5	35.49
40	35	6	41.41
40	40	7	47.32
40	45	8	53.24
40	50	9	59.16
40	55	10	65.07
40	60	11	70.99
40	65	12	76.90
40	70	13	82.82
40	75	14	88.73
40	80	15	94.65
40	85	16	100.56
40	90	16	106.48
40	95	17	112.39
40	100	18	118.31
40	105	19	124.23
40	110	20	130.14
40	115	21	136.06
40	120	22	141.97
40	125	23	147.89
40	130	24	153.80
40	135	25	159.72
40	140	26	165.63
40	145	27	171.55
40	150	27	177.47
40	155	28	183.38
40	160	29	189.30
40	165	30	195.21
40	170	31	201.13
40	175	32	207.04
40	180	33	212.96
40	185	34	218.87
40	190	35	224.79
40	195	36	230.70
40	200	37	236.62
40	205	38	242.54
40	210	38	248.45
40	215	39	254.37
40	220	40	260.28
40	225	41	266.20
40	230	42	272.11
40	235	43	278.03
40	240	44	283.94
40	245	45	289.86
40	250	46	295.78
40	255	47	301.69
40	260	48	307.61
40	265	49	313.52
40	270	49	319.44
40	275	50	325.35
40	280	51	331.27
40	285	52	337.18
40	290	53	343.10
40	295	54	349.01
40	300	55	354.93

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 41 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
41	0	0	0.0
41	5	1	5.95
41	10	2	11.91
41	15	3	17.86
41	20	4	23.82
41	25	5	29.77
41	30	6	35.73
41	35	7	41.68
41	40	8	47.64
41	45	9	53.59
41	50	10	59.55
41	55	11	65.50
41	60	11	71.45
41	65	12	77.41
41	70	13	83.36
41	75	14	89.32
41	80	15	95.27
41	85	16	101.23
41	90	17	107.18
41	95	18	113.14
41	100	19	119.09
41	105	20	125.05
41	110	21	131.00
41	115	22	136.96
41	120	23	142.91
41	125	24	148.86
41	130	25	154.82
41	135	26	160.77
41	140	27	166.73
41	145	28	172.68
41	150	29	178.64
41	155	30	184.59
41	160	31	190.55
41	165	32	196.50
41	170	32	202.46
41	175	33	208.41
41	180	34	214.36
41	185	35	220.32
41	190	36	226.27
41	195	37	232.23
41	200	38	238.18
41	205	39	244.14
41	210	40	250.09
41	215	41	256.05
41	220	42	262.00
41	225	43	267.96
41	230	44	273.91
41	235	45	279.86
41	240	46	285.82
41	245	47	291.77
41	250	48	297.73
41	255	49	303.68
41	260	50	309.64
41	265	51	315.59
41	270	52	321.55
41	275	53	327.50
41	280	53	333.46
41	285	54	339.41
41	290	55	345.36
41	295	56	351.32
41	300	57	357.27

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 42 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
42	0	0	0.0
42	5	1	5.99
42	10	2	11.99
42	15	3	17.98
42	20	4	23.98
42	25	5	29.97
42	30	6	35.97
42	35	7	41.96
42	40	8	47.96
42	45	9	53.95
42	50	10	59.95
42	55	11	65.94
42	60	12	71.94
42	65	13	77.93
42	70	14	83.93
42	75	15	89.92
42	80	16	95.92
42	85	17	101.91
42	90	18	107.91
42	95	19	113.90
42	100	20	119.90
42	105	21	125.89
42	110	22	131.89
42	115	23	137.88
42	120	24	143.88
42	125	25	149.87
42	130	26	155.87
42	135	27	161.86
42	140	28	167.86
42	145	29	173.85
42	150	30	179.85
42	155	31	185.84
42	160	32	191.83
42	165	33	197.83
42	170	34	203.82
42	175	35	209.82
42	180	36	215.81
42	185	37	221.81
42	190	38	227.80
42	195	39	233.80
42	200	40	239.79
42	205	41	245.79
42	210	42	251.78
42	215	43	257.78
42	220	44	263.77
42	225	45	269.77
42	230	46	275.76
42	235	47	281.76
42	240	48	287.75
42	245	49	293.75
42	250	50	299.74
42	255	51	305.74
42	260	52	311.73
42	265	53	317.73
42	270	54	323.72
42	275	55	329.72
42	280	56	335.71
42	285	57	341.71
42	290	58	347.70
42	295	59	353.70
42	300	60	359.69

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 43 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
43	0	0	0.0
43	5	1	6.04
43	10	2	12.07
43	15	3	18.11
43	20	4	24.15
43	25	5	30.18
43	30	6	36.22
43	35	7	42.25
43	40	8	48.29
43	45	9	54.33
43	50	10	60.36
43	55	11	66.40
43	60	12	72.44
43	65	13	78.47
43	70	15	84.51
43	75	16	90.55
43	80	17	96.58
43	85	18	102.62
43	90	19	108.66
43	95	20	114.69
43	100	21	120.73
43	105	22	126.76
43	110	23	132.80
43	115	24	138.84
43	120	25	144.87
43	125	26	150.91
43	130	27	156.95
43	135	28	162.98
43	140	29	169.02
43	145	30	175.06
43	150	31	181.09
43	155	32	187.13
43	160	33	193.16
43	165	34	199.20
43	170	35	205.24
43	175	36	211.27
43	180	37	217.31
43	185	38	223.35
43	190	39	229.38
43	195	40	235.42
43	200	41	241.46
43	205	42	247.49
43	210	44	253.53
43	215	45	259.56
43	220	46	265.60
43	225	47	271.64
43	230	48	277.67
43	235	49	283.71
43	240	50	289.75
43	245	51	295.78
43	250	52	301.82
43	255	53	307.86
43	260	54	313.89
43	265	55	319.93
43	270	56	325.97
43	275	57	332.00
43	280	58	338.04
43	285	59	344.07
43	290	60	350.11
43	295	61	356.15
43	300	62	362.18

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 44 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
44	0	0	0.0
44	5	1	6.08
44	10	2	12.16
44	15	3	18.24
44	20	4	24.32
44	25	5	30.40
44	30	6	36.48
44	35	8	42.56
44	40	9	48.63
44	45	10	54.71
44	50	11	60.79
44	55	12	66.87
44	60	13	72.95
44	65	14	79.03
44	70	15	85.11
44	75	16	91.19
44	80	17	97.27
44	85	18	103.35
44	90	19	109.43
44	95	21	115.51
44	100	22	121.59
44	105	23	127.67
44	110	24	133.75
44	115	25	139.82
44	120	26	145.90
44	125	27	151.98
44	130	28	158.06
44	135	29	164.14
44	140	30	170.22
44	145	31	176.30
44	150	32	182.38
44	155	33	188.46
44	160	35	194.54
44	165	36	200.62
44	170	37	206.70
44	175	38	212.78
44	180	39	218.86
44	185	40	224.93
44	190	41	231.01
44	195	42	237.09
44	200	43	243.17
44	205	44	249.25
44	210	45	255.33
44	215	46	261.41
44	220	47	267.49
44	225	49	273.57
44	230	50	279.65
44	235	51	285.73
44	240	52	291.81
44	245	53	297.89
44	250	54	303.97
44	255	55	310.05
44	260	56	316.12
44	265	57	322.20
44	270	58	328.28
44	275	59	334.36
44	280	60	340.44
44	285	62	346.52
44	290	63	352.60
44	295	64	358.68
44	300	65	364.76

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 45 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
45	0	0	0.0
45	5	1	6.12
45	10	2	12.25
45	15	3	18.37
45	20	4	24.49
45	25	6	30.62
45	30	7	36.74
45	35	8	42.87
45	40	9	48.99
45	45	10	55.11
45	50	11	61.24
45	55	12	67.36
45	60	13	73.48
45	65	15	79.61
45	70	16	85.73
45	75	17	91.86
45	80	18	97.98
45	85	19	104.10
45	90	20	110.23
45	95	21	116.35
45	100	22	122.47
45	105	24	128.60
45	110	25	134.72
45	115	26	140.85
45	120	27	146.97
45	125	28	153.09
45	130	29	159.22
45	135	30	165.34
45	140	31	171.46
45	145	33	177.59
45	150	34	183.71
45	155	35	189.84
45	160	36	195.96
45	165	37	202.08
45	170	38	208.21
45	175	39	214.33
45	180	40	220.45
45	185	42	226.58
45	190	43	232.70
45	195	44	238.83
45	200	45	244.95
45	205	46	251.07
45	210	47	257.20
45	215	48	263.32
45	220	49	269.44
45	225	51	275.57
45	230	52	281.69
45	235	53	287.81
45	240	54	293.94
45	245	55	300.06
45	250	56	306.19
45	255	57	312.31
45	260	58	318.43
45	265	60	324.56
45	270	61	330.68
45	275	62	336.80
45	280	63	342.93
45	285	64	349.05
45	290	65	355.18
45	295	66	361.30
45	300	67	367.42

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 46 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
46	0	0	0.0
46	5	1	6.17
46	10	2	12.34
46	15	4	18.51
46	20	5	24.68
46	25	6	30.85
46	30	7	37.02
46	35	8	43.19
46	40	9	49.36
46	45	11	55.53
46	50	12	61.70
46	55	13	67.87
46	60	14	74.04
46	65	15	80.21
46	70	16	86.38
46	75	18	92.55
46	80	19	98.72
46	85	20	104.88
46	90	21	111.05
46	95	22	117.22
46	100	23	123.39
46	105	25	129.56
46	110	26	135.73
46	115	27	141.90
46	120	28	148.07
46	125	29	154.24
46	130	30	160.41
46	135	32	166.58
46	140	33	172.75
46	145	34	178.92
46	150	35	185.09
46	155	36	191.26
46	160	37	197.43
46	165	39	203.60
46	170	40	209.77
46	175	41	215.94
46	180	42	222.11
46	185	43	228.28
46	190	44	234.45
46	195	46	240.62
46	200	47	246.79
46	205	48	252.96
46	210	49	259.13
46	215	50	265.30
46	220	51	271.47
46	225	53	277.64
46	230	54	283.81
46	235	55	289.98
46	240	56	296.15
46	245	57	302.32
46	250	58	308.48
46	255	60	314.65
46	260	61	320.82
46	265	62	326.99
46	270	63	333.16
46	275	64	339.33
46	280	66	345.50
46	285	67	351.67
46	290	68	357.84
46	295	69	364.01
46	300	70	370.18

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 47 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
47	0	0	0.0
47	5	1	6.22
47	10	2	12.43
47	15	4	18.65
47	20	5	24.87
47	25	6	31.09
47	30	7	37.30
47	35	9	43.52
47	40	10	49.74
47	45	11	55.96
47	50	12	62.17
47	55	13	68.39
47	60	15	74.61
47	65	16	80.83
47	70	17	87.04
47	75	18	93.26
47	80	19	99.48
47	85	21	105.70
47	90	22	111.91
47	95	23	118.13
47	100	24	124.35
47	105	26	130.56
47	110	27	136.78
47	115	28	143.00
47	120	29	149.22
47	125	30	155.43
47	130	32	161.65
47	135	33	167.87
47	140	34	174.09
47	145	35	180.30
47	150	37	186.52
47	155	38	192.74
47	160	39	198.96
47	165	40	205.17
47	170	41	211.39
47	175	43	217.61
47	180	44	223.83
47	185	45	230.04
47	190	46	236.26
47	195	47	242.48
47	200	49	248.69
47	205	50	254.91
47	210	51	261.13
47	215	52	267.35
47	220	54	273.56
47	225	55	279.78
47	230	56	286.00
47	235	57	292.22
47	240	58	298.43
47	245	60	304.65
47	250	61	310.87
47	255	62	317.09
47	260	63	323.30
47	265	65	329.52
47	270	66	335.74
47	275	67	341.96
47	280	68	348.17
47	285	69	354.39
47	290	71	360.61
47	295	72	366.82
47	300	73	373.04

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 48 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
48	0	0	0.0
48	5	1	6.27
48	10	3	12.53
48	15	4	18.80
48	20	5	25.07
48	25	6	31.33
48	30	8	37.60
48	35	9	43.87
48	40	10	50.13
48	45	11	56.40
48	50	13	62.67
48	55	14	68.94
48	60	15	75.20
48	65	16	81.47
48	70	18	87.74
48	75	19	94.00
48	80	20	100.27
48	85	22	106.54
48	90	23	112.80
48	95	24	119.07
48	100	25	125.34
48	105	27	131.60
48	110	28	137.87
48	115	29	144.14
48	120	30	150.40
48	125	32	156.67
48	130	33	162.94
48	135	34	169.21
48	140	35	175.47
48	145	37	181.74
48	150	38	188.01
48	155	39	194.27
48	160	41	200.54
48	165	42	206.81
48	170	43	213.07
48	175	44	219.34
48	180	46	225.61
48	185	47	231.87
48	190	48	238.14
48	195	49	244.41
48	200	51	250.67
48	205	52	256.94
48	210	53	263.21
48	215	54	269.47
48	220	56	275.74
48	225	57	282.01
48	230	58	288.28
48	235	60	294.54
48	240	61	300.81
48	245	62	307.08
48	250	63	313.34
48	255	65	319.61
48	260	66	325.88
48	265	67	332.14
48	270	68	338.41
48	275	70	344.68
48	280	71	350.94
48	285	72	357.21
48	290	73	363.48
48	295	75	369.74
48	300	76	376.01

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 49 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
49	0	0	0.0
49	5	1	6.32
49	10	3	12.64
49	15	4	18.95
49	20	5	25.27
49	25	7	31.59
49	30	8	37.91
49	35	9	44.23
49	40	11	50.55
49	45	12	56.86
49	50	13	63.18
49	55	15	69.50
49	60	16	75.82
49	65	17	82.14
49	70	18	88.46
49	75	20	94.77
49	80	21	101.09
49	85	22	107.41
49	90	24	113.73
49	95	25	120.05
49	100	26	126.37
49	105	28	132.68
49	110	29	139.00
49	115	30	145.32
49	120	32	151.64
49	125	33	157.96
49	130	34	164.28
49	135	36	170.59
49	140	37	176.91
49	145	38	183.23
49	150	40	189.55
49	155	41	195.87
49	160	42	202.19
49	165	44	208.50
49	170	45	214.82
49	175	46	221.14
49	180	47	227.46
49	185	49	233.78
49	190	50	240.10
49	195	51	246.41
49	200	53	252.73
49	205	54	259.05
49	210	55	265.37
49	215	57	271.69
49	220	58	278.01
49	225	59	284.32
49	230	61	290.64
49	235	62	296.96
49	240	63	303.28
49	245	65	309.60
49	250	66	315.92
49	255	67	322.23
49	260	69	328.55
49	265	70	334.87
49	270	71	341.19
49	275	73	347.51
49	280	74	353.82
49	285	75	360.14
49	290	76	366.46
49	295	78	372.78
49	300	79	379.10

APPENDIX C

DEPTH CORRECTIONS FOR A TRUE SLOPE OF 50 DEGREES

TRUE SLOPE (DEGREES)	ECHO DEPTH (FATHOMS)	INCREASE (FATHOMS)	TRUE DEPTH (FATHOMS)
50	0	0	0.0
50	5	1	6.37
50	10	3	12.74
50	15	4	19.12
50	20	5	25.49
50	25	7	31.86
50	30	8	38.23
50	35	10	44.60
50	40	11	50.97
50	45	12	57.35
50	50	14	63.72
50	55	15	70.09
50	60	16	76.46
50	65	18	82.83
50	70	19	89.21
50	75	21	95.58
50	80	22	101.95
50	85	23	108.32
50	90	25	114.69
50	95	26	121.07
50	100	27	127.44
50	105	29	133.81
50	110	30	140.18
50	115	32	146.55
50	120	33	152.92
50	125	34	159.30
50	130	36	165.67
50	135	37	172.04
50	140	38	178.41
50	145	40	184.78
50	150	41	191.16
50	155	43	197.53
50	160	44	203.90
50	165	45	210.27
50	170	47	216.64
50	175	48	223.02
50	180	49	229.39
50	185	51	235.76
50	190	52	242.13
50	195	54	248.50
50	200	55	254.87
50	205	56	261.25
50	210	58	267.62
50	215	59	273.99
50	220	60	280.36
50	225	62	286.73
50	230	63	293.11
50	235	64	299.48
50	240	66	305.85
50	245	67	312.22
50	250	69	318.59
50	255	70	324.96
50	260	71	331.34
50	265	73	337.71
50	270	74	344.08
50	275	75	350.45
50	280	77	356.82
50	285	78	363.20
50	290	80	369.57
50	295	81	375.94
50	300	82	382.31

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13. ABSTRACT

This study has as its final product a bathymetric chart of Carmel Bay, California, which is improved over any other previously existing chart. The unique problems of applying the echo-sounding corrections necessary to create accurate bathymetric charts of areas with steep bottom slopes are discussed.

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
CARMEL BAY, CALIFORNIA						
CARMEL SUBMARINE CANYON						
HYDROGRAPHIC SURVEY						
BATHYMETRIC SURVEY						
ECHO-SOUNDING						

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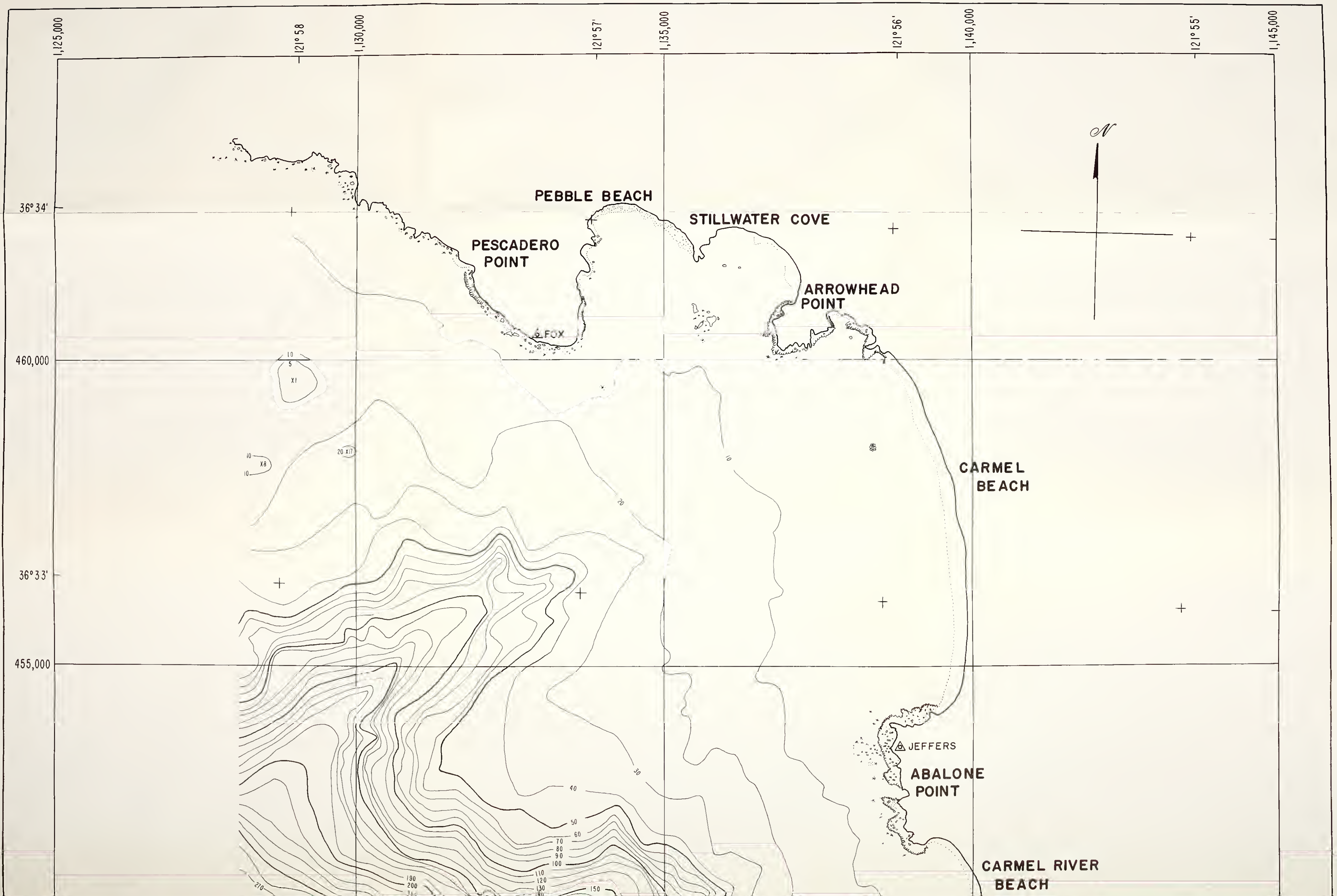
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1,130,000
121° 57'
1,135,000
121° 56'
1,140,000
121° 55'
1,145,000
N
36° 34'
460,000
36° 33'
455,000
PEBBLE BEACH
STILLWATER COVE
PESCADERO POINT
ARROWHEAD POINT
FOX
CARMEL BEACH
JEFFERS
ABALONE POINT
CARMEL RIVER BEACH
10
5
X1
10
X8
10
20 X17
10
20
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90
100
110
120
130
150
190
200
210

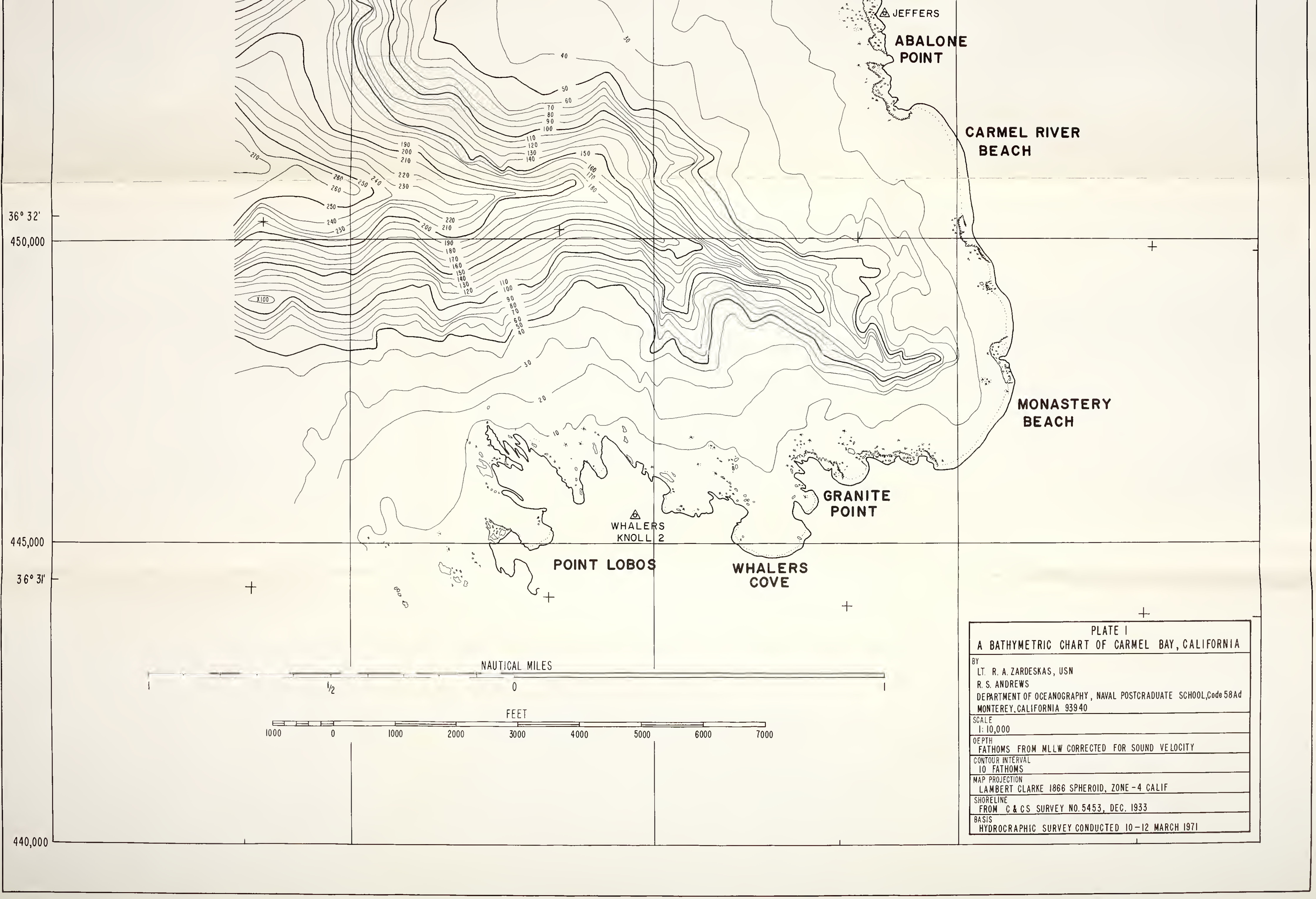
JEFFERS
ABALONE POINT
CARMEL RIVER BEACH
MONASTERY BEACH
GRANITE POINT
WHALERS KNOLL 2
POINT LOBOS
WHALERS COVE
36° 32'
450,000
445,000
36° 31'
440,000
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
X100
20
10
NAUTICAL MILES
1/2
0
1
FEET
1000
0
1000
2000
3000
4000
5000
6000
7000

PLATE I

A BATHYMETRIC CHART OF CARMEL BAY, CALIFORNIA

BY
LT. R. A. ZARDESKAS, USN
R. S. ANDREWS
DEPARTMENT OF OCEANOGRAPHY, NAVAL POSTGRADUATE SCHOOL, Code 58Ad
MONTEREY, CALIFORNIA 93940

SCALE
1: 10,000

DEPTH
FATHOMS FROM MLLW CORRECTED FOR SOUND VELOCITY

CONTOUR INTERVAL
10 FATHOMS

MAP PROJECTION
LAMBERT CLARKE 1866 SPHEROID, ZONE-4 CALIF

SHORELINE
FROM C & GS SURVEY NO. 5453, DEC. 1933

BASIS
HYDROGRAPHIC SURVEY CONDUCTED 10-12 MARCH 1971

130803

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